APPENDIX E. INTEGRATION OF ATIS TASKS A THROUGH E

BACKGROUND

Structure of the Project

This project was designed to develop human factors design guidelines for ATIS/CVO systems that are based on a thorough understanding of the characteristics and limitations of potential ATIS/CVO users. To accomplish this, the project is divided into three major phases. The first phase is analytical and is used to collect, evaluate, and understand the present state of knowledge concerning human capabilities and limitations as they will affect the use of ATIS/CVO systems. This phase is nearing completion and is the primary focus of this appendix. The second phase of the project will be a series of empirical studies designed to advance the level of understanding related to ATIS/CVO system use and human capabilities and use. This phase of the project will be undertaken over the next 2 years. The last phase will integrate the findings of the analytical and empirical work into a final report and human factors design guidelines.

Task Objectives

Each task in the ATIS/CVO project has its own objectives as well as those that support the primary goals of the project.

Task A. Literature Review. Task A had four major objectives:

- Identify human factors research issues, hypotheses, empirical findings, principles, and guidelines that are applicable to ATIS/CVO systems.
- Identify relevant documentation describing existing IVHS, ATMS, ATIS, and comparable system objectives, functions, and configurations.
- Identify present and likely near-term technological and cost constraints that will necessarily drive human factors-related ATIS/CVO issues.
- Identify existing guidelines, including an analysis of the known benefits and deficiencies arising from the use of these guidelines, that are relevant to ATIS/CVO systems.

Task B. System Objectives and Performance Requirements. Task B had three major objectives:

- Identify the transportation community's performance criteria that will be used to evaluate the successful design and implementation of fully operational ATIS/CVO systems.

- Identify the common and unique characteristics of the ATIS and CVO environments.

- Describe the transportation community's conceptualization of ATIS/CVO systems in terms of operational capabilities and projected benefits based on specified system performance objectives.

Task C. Function Description. Task C had two major objectives:

- Specify system functions required to achieve the objectives defined in Task B for ATIS/CVO systems. They shall encompass routine traveling conditions, emergency conditions, and high workload conditions.

- Consider (for each PRIVATE function) who makes decisions, the types of decisions, and how they are made; the current information resources; the willingness of users to provide information/work with system; and the types of data/responses desired as input and output.

Task D. Comparable Systems Analysis. Task D had five major objectives:

- Identify a minimum of five existing systems that include features and functions comparable to ATIS/CVO functions.

- Indicate the extent to which existing systems have comparable features, functions, and engineering design concepts with the proposed ATIS/CVO. Identify the areas that are not being addressed by the existing systems, the conflicts that have arisen during system design, and the conflicts among the various systems.

- Conduct an analysis of the lessons learned in design and development of the systems examined in terms of user interface, visual information display, auditory information display, user input, communications system, cognitive demands, and system temporal requirements.

- Recommend design specifications for: (1) displaying information in a vehicle, (2) storing and retrieving information needed for licenses and permits, and (3) communicating between the driver and ATMS, as well as between the driver and the fleet manager.

- Evaluate the effectiveness of human factors handbooks used by comparable system designers.

Task E. Task Analysis. Task E had two major objectives:

- Form a basis (along with Task F) for developing system design guidelines that will ensure that the tasks required of the user do not exceed his or her capabilities.

- Provide a detailed description of the way the user of the system needs to interact with the technology for the system to perform as intended.

Project Goals

The ATIS/CVO project as a whole has four primary objectives:

- Develop a precise and detailed set of human factors design guidelines to facilitate the development of safe, acceptable, and usable in-vehicle ATIS and CVO components of the IVHS.

- Help establish a common set of display standards across ATIS and ATMS, thereby ensuring the future inter-operability of these two systems.

  Assess what information travelers will need to make effective use of IVHS.

  Perform an assessment of what information travelers, drivers of both private and commercial vehicles, and system operators in commercial operations will need to receive from the Advanced Traffic Management Systems in order to make the decisions they want and/or need to make.

Research Issues

Many of the current ATIS/CVO human factors research issues have been identified in the strategic plan for IVHS in the United States (Department of Transportation, 1992). This strategic plan highlights the importance of human factors research and timely, appropriate guidance to designers of ATIS/CVO systems and other IVHS. Some issues of consideration are:

- Driver interface.
- Driver information.
- Behavioral issues.
- User demographics.
- Traffic management centers.

The 11 major research issues that have been identified as particularly important in the development of human factors design guidelines for ATIS are described below.

Issue 1: Existing Status of Research and Development

Both the development of guidelines and the implementation of ATIS will depend on the state of current technology and its application; therefore, an important issue for the development of human factors design guidelines is an understanding of the current state of development.

Issue 2: Formatting of Information

A key issue for the development of effective ATIS displays is the formatting of information. An understanding of the trade-offs involved in the use of various formats is important to the design of effective human factors design guidelines.

Issue 3: Driver Capacity to Assimilate Information

Developing an understanding of the capacity of drivers to assimilate and use information provided by ATIS is an important prerequisite to developing effective human factors design guidelines.

Issue 4: Knowledge, Skills, and Abilities Requirements

Understanding the knowledge, skills, and abilities needed to use ATIS/CVO systems is an important prerequisite to developing human factors design guidelines.

Issue 5: Information Requirements of ATIS/CVO Users

A comprehensive understanding of the information needs of ATIS/CVO users is necessary to developing human factors design guidelines that adequately represent those requirements.

Issue 6: Driver Acceptance of ATIS/CVO

Understanding the characteristics that will encourage driver acceptance of ATIS/CVO systems and compliance with recommendations provided by the system is an essential prerequisite to developing human factors design guidelines that adequately reflect those characteristics.

Issue 7: Driver Decision Strategies for Trip Taking

Understanding the strategies that drivers use to: (1) integrate information from several sources and several modalities, (2) engage in multi-task performance, (3) act as a supervisory controller, and (4) make decisions in rapidly changing dynamic environments is important to developing human factors design guidelines for ATIS/CVO systems.

Issue 8: Factors Influencing the Performance of Drivers

In order to develop useful human factors design guidelines for ATIS/CVO systems, it is essential to understand the factors that influence driver performance. Of particular interest are the factors that may be associated with age.

Issue 9: Issues Related to CVO System Use

Developing an understanding of the specific conditions of ATIS/CVO use by commercial truckers, emergency vehicle operators, and others is important to the development of human factors design guidelines that will be appropriate for systems used in commercial vehicles.

Issue 10: Interactions Between ATIS Use and Driving

Understanding the way drivers use ATIS/CVO systems in association with driving tasks is an essential requirement for developing human factors design guidelines that will maintain and enhance driving safety.

Issue 11: ATIS System Interactions

Understanding how the various systems within ATIS will interact with one another is important to the development of human factors design guidelines.

FINDINGS AND OBSERVATIONS RELATED TO PROJECT GOALS AND TASK OBJECTIVES

Findings and Observations Related to Project Goals

The current state of human factors design guidelines suitable for use in development of safe, acceptable, and usable in-vehicle ATIS/CVO components of the IVHS is characterized by the availability of considerable numbers of disorganized and often conflicting guidelines that have potential application, but are obviously flawed in this application. The ATIS project identified many of these guidelines and more are discovered as the project progresses. At this point in the project, it appears that two issues will need to be developed related to the guidelines.

- Little is known about how guidelines are used by designers. Resolution of this issue is important, because to actually influence the design of ATIS/CVO systems guidelines developed by this project, their presentation will need to be compatible with the designers' needs.

- Conflicting guidelines and design situations for which no guidelines exist will need to be resolved.

Although traveler information needs will be analyzed further in the context of the national survey that was developed as part of Task F, initial indications from the focus group exercises conducted as part of Task C indicate that two distinctly different sets of information are needed by the CVO community and private drivers. The primary basis for these differences appears to be the relative mobility of the two types of vehicles and differences in the regulatory requirements that apply to each. Present systems that support ATIS development, particularly those related to IRANS and IMSIS, are most appropriate to private vehicle operations. This is particularly true of the map data bases that support IRANS data bases.

Whether CVO-related restrictions and other information would support CVO use of an IRANS would simply be a matter of adding information to these data bases or developing a different data base. The potential importance of ATIS use by commercial vehicle operators in achieving IVHS objectives makes the apparent lack of attention to CVO-specific requirements in the ATIS support structure a cause for concern.

Both private and CVO users of the ATIS require a traffic management infrastructure that is consistent across geo-political boundaries. One of the major problems that is likely to face the ATIS as it reaches the point in development where ATMS information is used by the system will be the lack of effective inter-agency and multi-district coordination. For CVO systems, this coordination will mean that common standards for permits, vehicle documentation, vehicle condition requirements, and related regulatory activities will have to be developed.

Findings Related to Task Objectives

Findings Related to Task A. Literature Review

The primary findings related to Task A were that the scientific literature presently available for ATIS/CVO systems is primarily oriented toward descriptions of the system and not how it will be used.

There are several ongoing demonstration projects for ATIS/CVO systems. These projects are primarily based on the demonstration of single functions (e.g., route planning, route guidance, weigh in motion, or automatic toll collection). Most of the IRANS demonstration projects do not include traffic or road condition information.

The IVHS functional design concept is still being developed with the attendant problem that basic issues related to function and task allocation are poorly developed.

Whereas IRANS, IMSIS, and many CVO subsystems of ATIS are well defined and far enough into the development stage to have prototype and even operational systems available, the ISIS and IVSAWS are just beginning to reach this stage of development. The probable reason for this is that warning and notification systems require significant infrastructure support and have less direct commercial viability. The potential importance of these systems

to IVHS objectives indicates that they may require additional support from government sources than would be required by systems with more direct consumer appeal.

Findings Related to Task B. System Objectives and Performance Requirements

The transportation community expressed some difficulty in establishing performance criteria for evaluating the success of the design and implementation of fully operational ATIS/CVO systems. Although the community has historical measures of performance (e.g., accidents per passenger mile), they have not developed the cut-off criteria they would use to indicate success. The most likely source of such criteria will be the various cost/benefit analyses that will be done when the infrastructure to support full system implementation is done.

The transportation community had different, though perhaps interrelated assessments of the relative importance of achieving IVHS/ATIS objectives. For private applications, the community rated the IVHS goals in the following order of importance: (1) decrease traffic congestion, (2) increase safety, and (3) increase and provide a higher quality of transportation mobility. For CVO applications, the community rated the IVHS goals in the following order of importance: (1) increase economic productivity, and (2) increase safety. In both the private and CVO applications, the goals of improving environmental quality and energy conservation were considered the least important objectives of the system.

Of ATIS subsystems for both private and CVO applications, IRANS was considered a significantly more important system than the other three. The basis for this appeared to be perceptions of the possible contribution that IRANS would make to a reduction in traffic congestion, safety, and mobility. Since little empirical or systematic analysis has been done on how each system would contribute to each of the problems addressed by the IVHS goals, it is difficult to know if this assessment of the importance of IRANS is justified.

Findings Related to Task C. Function Description

This task provided two general results: (1) a general framework for describing mappings between different levels of system description, and (2) a comprehensive description of ATIS functional characteristics and their interaction.

In addition to characterizing the mapping between levels of abstraction, the functional description also depicts interactions between elements at several levels of description. Most importantly, Task C describes interactions between functional characteristics. In many cases, these interactions are positive; the value of any one functional characteristic is enhanced by others that are implemented simultaneously. However, the potential for many negative interactions exists as well. For example, route and destination selection will likely facilitate route guidance. Conversely, incorporating a multitude of advertising messages in in-vehicle displays may inhibit the driver's ability to assimilate hazard warning information. These interactions suggest that an integrated design philosophy is needed to avoid a piecemeal approach that will result in multiple elements that compete for the driver's limited attention.

Failing to integrate and prioritize the information provided by the various elements of an ATIS will potentially overwhelm the driver with information.

As a functional description of ATIS, the analysis focused on the functional level of abstraction; a level that is abstract enough not to specify a particular physical system, but concrete enough to identify general mechanisms and decision processes that might occur with an ATIS. Therefore, the mapping between levels of abstraction begins with the functional characteristics. Understanding the mapping between the functional characteristics of ATIS and the higher levels of abstraction depends on establishing how well ATIS functional characteristics achieve the overall IVHS goals. Similarly, understanding the mapping between ATIS functions and a description of ATIS at a lower level of abstraction involves identifying how functional characteristics may be realized in terms of physical components, such as video screens and push-button controls. For example, the functional characteristic route guidance may serve the goals of increased mobility and decreased congestion. Similarly, a synthetic voice, Liquid Crystal Display (LCD) icon, or high-resolution Cathode Ray Tube (CRT) might all be used to generate this functional characteristic.

While Task C identified prototypical decision cycles that would likely occur with individual functions, it did not address transitions between functions. These transitions may require unexpectedly large efforts on the part of the driver (i.e., remembering information to transfer from one element of the ATIS to another). These transitions will be especially important when driving, as drivers' attentional resources are already shared among several tasks.

Findings Related to Task D. Comparable Systems Analysis

Comparable systems that were evaluated include two that are prototypes of the IRANS/IMSIS. These evaluations indicate that relatively naive drivers using these systems performed better when using certain display configurations (i.e., combined audio and visual displays of guidance information) than when using other combinations.

The comparable systems analysis of the TravTek prototype IRANS/IMSIS indicates that, in terms of driver perception, "near-miss" observations and accident data that make use of these systems need not degrade safe driving performance.

Existing prototype IRANS/IMSIS are limited by the accuracy of the data bases currently available to support them. In both of the prototypes, the navigation data base provided guidance instructions that were either not legal (e.g., directing travel the wrong way on a one-way street) or impossible (e.g., directing a turn at a cross-street from an underpass with no entry ramp).

One of the comparable systems (OmniTRACS) had been designed using customer requirements as the primary design guide. In this case, the system design requirements were largely established by commercial trucking fleet managers. Therefore, some of the features of the system (i.e., ease of installation in different truck configurations, use of a standard keyboard, and use of a rugged but physically limited display) are not designed with the user

in mind. This implies that ATIS/CVO systems need to be designed for both marketability (i.e., to meet buyers' requirements) and use.

The major standard used by the designers of comparable systems has been MIL-STD 1472 and related documents. For many of the designs, this standard has provided a starting point for control and display features, but it does not provide necessary guidance in such areas as digitized map displays. Perhaps more importantly is the fact that MIL-STD 1472 deals almost exclusively with the mechanical aspects of the design and does not properly consider the effect of workload and multi-task activities.

Findings Related to Task E. Task Analysis

The development of a task analysis for ATIS/CVO systems is both an important and efficient way to gather information that can be used in developing human factors design guidelines. The level of detail and, therefore, the potential uses of the task analysis are dependent on the state of development of the system under consideration. In the case of IRANS destination planning and route guidance functions, prototype systems provide a reasonable basis on which to build the task analysis. The same is also true for use of IMSIS services directories and some advanced CVO systems. Less developed systems such as ISIS and IVSAWS have no prototypes upon which to base a task analysis. At the present time, these systems also lack sufficiently well-established system design requirements to provide the basis for a task analysis based on prospective techniques without running a significant risk. This implies that task analyses of ATIS/CVO systems should be an interactive process that is repeated as the system design requirements are specified and prototypes are developed.

The task analysis in Task E was developed using the "decision element" approach previously used in Task C as the basis for categorizing human actions. This approach was adopted to maintain continuity between the tasks. While the approach had significant advantages for the project, it appeared during the analysis that there are some limitations to the "decision element" approach when applied to more general descriptions of what a driver does with the system. In particular, use of the "decision element" approach appears to be better suited to descriptions of tasks at a lower level in a task hierarchy than was possible in this analysis. Future task analyses along this line might benefit from use of a different taxonomy of driver actions.

FINDINGS RELATED TO RESEARCH ISSUES

Findings Related to Issue 1: Existing Status of Research and Development

Findings from Task A. Literature Review

- The ATIS/CVO literature review is very much oriented towards a system description.

- There are several demonstration projects in progress.
- Some basic aspects of the IVHS are still being defined.
- There is a gap in the research for IVSAWS and ISIS in general.
- Research status for ATIS/CVO systems is mixed. Both are relatively new, yet both are in operational test phases due to the public-private partnership specified in the IVHS Strategic Plan.
- ATIS/CVO research to date has tended to be system description-oriented, with details of the organization of research that is being or needs to be conducted.
- There are many human factors research issues that remain to be addressed before a comprehensive set of guidelines can be developed.
- ATIS research and development (R&D) will focus on navigation software, map and services data bases, and communications alternatives.
- Operational testing is now occurring on navigation route planning.
- Identification/location (AWAVL) and delivery modes systems have undergone testing and are now becoming operational.
- CVO R&D will focus on weigh in motion (WIM), electronic toll collection, driver warning, and electronic recordkeeping.
- Operational testing is now underway for AWAVL, electronic credential checking, and electronic permitting.
- The majority of IVHS literature produced to date contains descriptions of research plans and proposed frameworks for evaluating systems.
- Many of the initial operational tests are still under way and no empirical findings are currently available.
- Few documents discuss specific design guidelines or empirical results related to safety and human factors of ATIS/CVO systems.

Findings from Task E. Task Analysis

- Task analyses of prototype ATIS have either not been performed or are not available.

- Methodologies for performing task analyses of systems that have poorly specified operational and physical characteristics have not been developed.

Findings Related to Issue 2: Formatting of Information

Findings from Task A. Literature Review

- Some studies indicate that either symbolic guidance displays or textual lists are easier to use than maps while navigating to unknown destinations. Note, however, that maps provide additional information that textual lists do not. Therefore, whether a map, symbolic guidance screen, or list is selected should necessarily depend on the desired task and required information.

- Literally thousands of design guidelines apply, at least to some extent, to the formatting of ATIS/CVO systems. Developing a way to organize this information and eliminate conflicting guidelines is a major problem in the development of human factors design guidelines for ATIS.

Findings from Task C. Function Description

- Because complex mapping exists between functions and the physical aspects of the systems, a variety of mechanisms could be used to implement ATIS/CVO functions. The relative efficiency and desirability of each of these mechanisms are potential issues for further research.

Findings from Task E. Task Analysis

- Route review and approval requirements should be supported by a display that depicts the whole or large parts of the recommended route on a single display.

- System design should include positive indications to the driver that a change of function (e.g., shift from planning to route guidance or change in destination routing) has occurred following driver actions that initiate such a change.

Findings Related to Issue 3: Driver Capacity to Assimilate Information

Findings from Task B. System Objectives and Performance Requirements

- Respondents to the interviews expressed a concern that in-vehicle ATIS introduction might cause excessive mental workload requirements in the case of heavily instrumented commercial vehicles, especially emergency vehicles.

- Respondents to the interviews stated that ATIS could reduce the frequency of drivers simultaneously holding a map or a portable hand-held system while driving, which the respondents cited as an unsatisfactory and unsafe condition.

Findings from Task C. Function Description

- Since drivers, dispatchers, regulators, and managers represent system elements that are integral to ATIS/CVO functions, it is important **to** consider how knowledge, attitudes, and perceptual, motor, and decision-making limitations might compromise system functions and objectives.

- Human constraints need to be addressed in the human factors design guidelines.

Findings Related to Issue 4: Knowledge, Skills, and Abilities Requirements

Findings from Task E. Task Analysis

- Tasks to initiate ATIS/CVO systems involve relatively limited knowledge and skill requirements.

- Tasks to code uncataloged destinations and select common services from large lists of possibilities will require both specialized information (e.g., geographical area name) and the ability to accurately remember relatively complex information long enough to complete the destination entry process.

- Tasks associated with review and approval of route recommendations will require some knowledge of map reading, an understanding of the way that the system selects routes, and an ability to visualize how the route will proceed.

- Use of IRANS route guidance functions will require that the driver maintain situational awareness and alertness to driving hazards.

- Whereas some ATIS functions (e.g., route planning and guidance) will require increased knowledge and skills by the driver, some will effectively reduce those requirements.

Findings Related to Issue 5: Information Requirements of ATIS/CVO Users

Findings from Task C. Function Description

- There is a need to consider requirements imposed by the environment (e.g., weather and crime-prone areas) as part of the information that drivers need.

- There are major differences in the type of information required by commercial drivers as opposed to private drivers.

Findings from Task E. Task Analysis

- Alternative methods for entering destination information (e.g., bar coding of business cards, cross-referencing with telephone numbers, and pre-loaded smart cards) other than direct entry by the driver should be supported and encouraged.

- A standard taxonomy of IMSIS categories should be developed and used throughout the data bases.

- System design should include positive indications to the driver that a change of function (e.g., shift from planning to route guidance, or change in destination routing) has occurred following driver actions that initiate such a change.

- Provisions should be made in the system to allow the driver not only to review a proposed route, but to review the assumptions made by the system when establishing that route.

- Driver-set preferences should be designed to require drivers to select a preference rather than exclude a preference. This would reduce the number of features, notifications, and warnings that are presented to the driver.

- Setup features for IRANS should include the ability to enter and retain short lists of frequently selected destinations and routes.

Findings Related to Issue 6: Driver Acceptance of ATIS/CVO

Findings from Task B. System Objectives and Performance Requirements

- Respondents to the interviews suggested that a portable ATIS might be introduced as an emergency technology, which could facilitate driver acceptance prior to the introduction of dedicated in-vehicle systems.

- Surveys indicate that most commuters see IVHS as a possible solution to traffic congestion.

- Introduction of the technology should first be made using less complex systems that include limited subsets of ATIS subsystems. This would both reduce initial costs and provide an introduction to the technology.

Findings from Task C. Function Description

- Driver acceptance will depend on the driver's trust of automation.

- Driver acceptance will depend on the driver's confidence in his or her ability to effectively use the system.

Findings from Task E. Task Analysis

- Use of sophisticated ATIS/CVO functions (e.g., manual aid) to replace existing technology (e.g., cellular phone) is considered unnecessary.

- Use of preference profiles for individuals and situations should be encouraged to reduce setup time for the driver.

- Setup features that involve entry of specific information by the driver, such as street names and addresses, should include checking functions that will assist the driver in identifying errors and correcting the entry. Since the driver may or may not have precise information available when initiating the system, this checking function should provide logical alternatives to an error, when available.

Findings Related to Issue 7: Driver Decision Strategies for Trip Taking

Findings from Task A. Literature Review

- Drivers have been shown to be resistant to diverting from their present route to avoid congestion. However, some navigation system characteristics can effectively change the driver's behavior.

Findings from Task C. Function Description

- The diversity of functions associated with ATIS/CVO systems reflect a diversity in the types of decisions that will need to be made.

- Decision strategies need to be expressed within a theoretical framework in order to be understandable.

Findings from Task E. Task Analysis

- Destination selection should include the possibility of the driver using successive approximation approaches to destination selection. Such an approach would allow the driver first to receive guidance to a general area (e.g., a downtown district) and then to use IMSIS broadcast services or a services directory to select a final destination.

Findings Related to Issue 8: Factors Influencing the Performance of Drivers

Findings from Task A. Literature Review

- The in-transit functions should be limited to necessity and convenience. In fact, all efforts must be made to limit the functionality of the in-transit mode to those tasks that: (1) do not significantly interfere with the driving task, (2) have convenience benefits that outweigh the cost of including the function, and (3) will be used frequently.

- Subjects using complex navigational devices drove more slowly than those using less complex devices. These effects were also more prevalent in older drivers than in younger drivers.

- Special consideration must be given to older drivers. Minimization of glance time in design of a navigation information display is critically important, as it was found that elderly drivers spend twice as much time looking at a given display.

Findings from Task C. Function Analysis

- The public will tolerate little in the way of training associated with ATIS/CVO use.

Findings from Task E. Task Analysis

- A complete understanding of how ATIS/CVO systems might influence driving performance depends on addressing the broader tasks of driving by describing the interaction of ATIS-specific and driving-specific tasks.

- Access to functions and features should be based on an assessment of the combined workload requirements of each feature and the likely driving conditions that would encourage using the function.

- Both the information requested of the system and the display provided when making system recommendations should be compatible with other demands on the driver at the time, even though this might mean that system recommendations would be less than optimal.

Findings Related to Issue 9: Issues Related to CVO System Use

Findings from Task A. Literature Review

- Several dispatching and routing navigation systems are in existence for CVO applications.

Findings from Task B. System Objectives and Performance Requirements

- The least important objective for private applications-economic productivity-was rated the most important objective for CVO applications.

Findings from Task C. Function Analysis

- Most ATIS functional characteristics apply to both private and CVO drivers. In most cases, CVO applications differ only slightly at the level of system physical features.

- The restrictions of CVO equipment and operations will require different levels of support at the data base and infrastructure level of ATIS/CVO system design.

- There are major differences in the type and level of detail needed for CVO as opposed to private driving applications of ATIS.

Findings Related to Issue 10: Interactions Between ATIS Use and Driving

Findings from Task C. Function Analysis

- A complete understanding of how ATIS/CVO systems might influence driving performance depends on addressing the broader tasks of driving by describing the interaction of ATIS-specific and driving-specific tasks.

- Functional descriptions and scenarios provide a starting point for considering the task demands associated with assessing and responding to ATIS/CVO information in the driving context.

Findings Related to Issue 11: ATIS Interactions

Findings from Task B. System Objectives and Performance Requirements

- Interviews with the driving community indicate that IRANS is judged to have a central role in meeting ATIS objectives for both private and CVO applications, especially in decreasing traffic congestion.

- There are at least four interrelated ATIS architecture issues in developing a unified system architecture: (1) data flows between ATIS and ATMS, (2) the distribution of ATIS functions, (3) data flows among ATIS subsystems, and (4) IVHS and ATIS maturity.

Findings from Task C. Function Analysis

- There are both positive and negative interactions among ATIS/CVO functions.
- There are both positive and negative interactions within and among ATIS/CVO subsystems.
- The value of a function and its performance may depend on how functions are paired and integrated into an ATIS/CVO system.
- Most use of ATIS/CVO will require the use of more than one function.

RECOMMENDATIONS

Recommendations Related to Human Factors Design Guidelines

The human factors design guidelines will need to be presented in a way that allows rapid and efficient indexing and accessing of the particular information of interest. Present guidelines are far too complex and difficult to access for designers to use except when an issue of critical importance has been highlighted. In the past, this has often been done through the mechanism of the military procurement system, which provided economic stimulus for designers and manufacturers to comply with both guidelines and standards even when producing a product for civilian use. As military procurement becomes less important to the development of systems, however, the use of guidelines such as are being developed in this project will depend primarily on their perceived usefulness and ease of use to the designer.

Recommendations Related to Research Issues

For ISIS and IVSAWS, there has been no research done on the type of information that should be displayed to the driver. There should be additional research done on the nature and requirements regarding the time and content of the information presented to the user.

Modeling of ATIS/CVO system use remains an open research issue.

CVO drivers can be trained. As a consequence, they can be given more information to work with, they can handle more information better, and they can make better use of that information than untrained private drivers. However, how much is too much?

Additional research is still needed to determine what information the driver needs to have displayed, what mode of display should be used, and when the driver should have access to the information. It is particularly important that this research be done in connection with simulated or actual driving requirements.

A driver's capacity varies over time due to the dynamic nature of the task. Research needs to be done to determine how ATIS can capitalize on the fluctuating availability of driver cognitive capacity. During periods of low driving demand, systems should utilize the excess capacity available, while at the same time avoiding overloading the driver with system demands during periods of lowered cognitive capacity.

Little is known of the actual safety consequences, benefits, and costs associated with ATIS/CVO system implementation. Developing an understanding of the likely consequences of system implementation is a necessary prerequisite to the development of an infrastructure that will support ATIS/CVO systems. Decisions about how the infrastructure will be developed and what features it will include are, in turn, necessary prerequisites to the development of the final design characteristics that will be used for in-vehicle equipment.

Research into driver acceptance of ATIS/CVO systems is still a major area that needs to be developed, both to determine the economic and political viability of the systems and to determine how much they will be used.

The ATIS/CVO systems probably represent the first major technological system for which there is a real need to develop systems that require little or no training for their use. Both from the standpoint of driver acceptance and as a practical matter of eliminating the need for developing a training infrastructure to support the system, these systems must be designed to minimize training requirements to an extent not previously attempted. Research is needed on both how to design the systems to avoid the need for training and how to provide training that may be needed in the most efficient manner possible.

Navigation strategies used for ATIS route guidance that focus on the destination are different than those normally used by drivers, who tend to focus on the successive process of approaching a destination by using a series of recognizable waypoints. How prolonged use of destination-focused approaches will affect driver reliance, comfort, and use of ATIS/CVO systems needs to be explored, both in terms of driver acceptance and driver stress.

Under some conditions, ATIS/CVO recommendations are likely to exceed the ability of the driver to follow them (e.g., a driver is unable to make a required turn due to traffic). Since efficient use of ATIS will depend on an understanding of the best strategies for recovering from this type of event, it is important to understand how drivers deal with such events now and how ATIS might be used to improve such strategies.

As the state of ATIS development progresses, task analyses should be conducted on prototype systems to better understand and evaluate how drivers will use these systems.